

1 CLAIMS

2 I claim:

- 3 1. An apparatus for filtration of water from hydrocarbons comprised of  
4 a) a fresh-feed inlet,  
5 b) a first dead end filter, having a filter medium that is hydrophobic,  
6 c) a second cross-flow filter, having a membrane that is hydrophobic,  
7 d) a common housing to contain both the first and second filters,  
8 e) a system for the recirculation of the retentate,  
9 f) a chamber for water settling, and  
10 g) an outlet for clean fuel permeate.

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12 2. The filtration apparatus as set forth in claim 1, further characterized by a ratio  
13 of cross-flow to fresh-feed in the range of 1:1 to 1:30.

- 14  
15 3. The filtration apparatus as set forth in claim 1, wherein the pressure differential  
16 between the feed pressure and the permeate pressure is less than or equal to  
17 50psi.

- 18  
19 4. The filtration apparatus as set forth in claim 1, wherein the operating  
20 temperature is maintained below or equal to 130 degrees Fahrenheit.

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1 5. The filtration apparatus as set forth in claim 1, wherein said first dead end filter  
2 is made from a material selected from the group consisting of nylon, polyester,  
3 polyvinylidene difluoride and polypropylene.

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5 6. The filtration apparatus as set forth in claim 1, wherein said first dead end filter  
6 has a pore size in the range of 0.5  $\mu\text{m}$  to 100  $\mu\text{m}$ .

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8 7. The filtration apparatus as set forth in claim 1, in which said second cross-flow  
9 filter is of a type selected from the group consisting of spiral wound module  
10 cartridges, tubular cartridges and hollow fiber cartridges.

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12 8. The filtration apparatus as set forth in claim 1, in which said second  
13 hydrophobic cross-flow filter is made from polytetrafluoroethylene membrane.

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15 9. The filtration apparatus as set forth in claim 8, further characterized by the  
16 polytetrafluoroethylene membrane having a sub micron pore size.

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18 10. The filtration apparatus as set forth in claim 8, wherein the  
19 polytetrafluoroethylene membrane is of 0.1  $\mu\text{m}$  pore size.

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21 11. An apparatus for filtration of water from hydrocarbons comprised of  
22 a) a top chamber;  
23 b) a feed chamber;

- 1 c) a chamber for water settling;
- 2 d) a permeate chamber;
- 3 e) a fresh-feed inlet, communicating with said feed chamber;
- 4 f) a first dead end filter, having a filter medium that is hydrophobic,
- 5 communicating on its inlet side with said feed chamber and on its outlet
- 6 side with said top chamber;
- 7 g) a perforated tube sleeve guide containing said first dead end filter;
- 8 h) a second cross-flow filter, having a membrane that is hydrophobic,
- 9 communicating on its inlet end with said top chamber and on its outlet
- 10 end with a said chamber for water settling, which filter is further
- 11 characterized by having a center tube for collection of permeate,
- 12 communicating with said permeate chamber;
- 13 i) a non-perforated tube sleeve guide, containing said second cross-flow
- 14 filter;
- 15 j) a common housing to contain both said first and second filters,
- 16 including an elongate housing wall having opposed first and second
- 17 open ends, an elongate cylindrical interior surface defining a housing
- 18 cavity, and a series of plates extending across said open ends of said
- 19 housing wall, defining said chambers;
- 20 k) a system for the recirculation of the retentate, including a port for outlet
- 21 of the concentrate in fluid communication with said chamber for water
- 22 settling, a circulation pump and a feed inlet having fluid communication
- 23 with the feed chamber in the housing; and

1            l) an outlet for clean fuel permeate in fluid communication with said  
2            permeate chamber.

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4    12.    The apparatus for filtration of claim 11, further characterized by a ratio of  
5           cross-flow to fresh-feed in the range of 1:1 to 1:30.

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7    13.    The apparatus for filtration of claim 11, wherein the pressure differential  
8           between the feed pressure and the permeate pressure is less than or equal to  
9           50psi.

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11   14.    The apparatus for filtration of claim 11, wherein the operating temperature is  
12           maintained below or equal to 130 degrees Fahrenheit.

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14   15.    The apparatus for filtration of claim 11, wherein said first dead end filter has a  
15           pore size in the range of 0.5  $\mu\text{m}$  to 100  $\mu\text{m}$ .

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17   16.    The apparatus for filtration of claim 11, in which said second hydrophobic  
18           cross-flow filter is made from polytetrafluoroethylene membrane.

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20   17.    The apparatus for filtration of claim 16, wherein the polytetrafluoroethylene  
21           membrane is of 0.1  $\mu\text{m}$  pore size.

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23   18.    An apparatus for filtration of water from hydrocarbons comprised of

- 1 a) a fresh-feed inlet,
- 2 b) a plurality of first dead end filters, having filter media that are
- 3 hydrophobic,
- 4 c) a plurality of second cross-flow filters, having membranes that are
- 5 hydrophobic,
- 6 d) a common housing to contain said first and second filters,
- 7 e) a system for the recirculation of the retentate,
- 8 f) a chamber for water settling, and
- 9 g) an outlet for clean fuel permeate.

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11 19. An apparatus for filtration of water from hydrocarbons comprised of

- 12 a) a fresh feed inlet,
- 13 b) a first dead end filter, having a filter medium that is hydrophobic, in
- 14 series with a second cross-flow filter, having a membrane that is
- 15 hydrophobic, each filter being disposed within a separate housing,
- 16 c) a system for the recirculation of the retentate,
- 17 d) a chamber for water settling, and
- 18 e) an outlet for clean fuel permeate.

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20 20. A method for removal of water from hydrocarbon liquid fuels containing

21 surfactants, comprising the steps of

- 22 a) passing a water emulsion-containing fuel through a first hydrophobic
- 23 filter,

- 1 b) coalescing water in said first hydrophobic filter to form large globules,
- 2 c) carrying away agglomerated water globules in the flow stream between
- 3 the first and second filter,
- 4 d) excluding water globules at the surface of a cross-flow hydrophobic
- 5 filter, and
- 6 e) passing water-free hydrocarbon liquid through said cross-flow
- 7 hydrophobic filter.

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- 9 21. The method of filtration as set forth in claim 20, wherein the hydrocarbon is
- 10 selected from the group consisting of jet fuel, diesel fuel, and gasoline.
- 11
- 12 22. The method of filtration as set forth in claim 20, wherein the pressure
- 13 differential between the feed pressure and the permeate pressure is less than or
- 14 equal to 50psi.
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- 16 23. The method of filtration as set forth in claim 20, wherein the operating
- 17 temperature is maintained below or equal to 130 degrees Fahrenheit.
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- 19 24. A filter apparatus for the coalescing of water emulsified by a surfactant,
- 20 comprised of a filter with a hydrophobic filter medium having a surface energy
- 21 near to or less than that of the hydrophobic functional group of said surfactant.